N° 9005 A.D. 1915

Date of Application, 18th June, 1915

Complete Specification Left, 18th Jan., 1916—Accepted, 19th June, 1916

PROVISIONAL SPECIFICATION.

Improvements in and relating to Partial Admission Turbines.

We, The Honourable Sir CHARLES ALGERNON PARSONS, K.C.B., Engineer, of Heaton Works, Newcastle-on-Tyne, in the County of Northumberland, STANLEY SMITH COOK, Engineer, and ROBERT HOWE, Engineer, both of Turbinia Works, Wallsend-on-Tyne, in the County of Northumberland, do hereby declare the nature of this invention to be as follows:—

The present invention relates to partial admission turbine stages of the type in which the working fluid expands chiefly within the first guide means, the velocity energy and the residual pressure energy being subsequently fractionally absorbed in one or more rows of moving blades with alternated rows of stationary blades.

The present invention relates to partial admission turbine stages of the type in which the working fluid expands chiefly within the first guide means; the expansion which takes place in the successive moving and stationary blades being only a slight fraction of the total expansion of that stage.

The present invention consists in a turbine stage of the type indicated, in which short end blockings are employed, such as are described in the Specification of Letters Patent No. 28,047 of 1907, together with end tightening means for the blades such as are described in the Specification of Letters Patent No. 12,347 of 1901, whereby the loss by spilling over the blades, and the leakage through the clearance spaces surrounding the blades, are reduced.

The invention further consists in a turbine having an initial stage constructed according to the preceding paragraph succeeded by a stage or stages of ordinary "Parsons" reaction blading, some or all of these latter stages being of either the partial admission type, or of the annular admission type.

The invention further consists in a turbine stage according to the third paragraph, in which the outer face of the nozzle is placed in contact with the stator carrying the guide blades, labyrinth or other suitable form of packing being provided between the nozzle and the adjacent part of the rotor, whereby leakage of steam from the space between the nozzle and the first row of blades is prevented or considerably reduced.

The invention further consists in turbine stages or turbines, as described in the last three paragraphs, in which either or both of the inlet and exit sides of the blades have prolongations of the constraining walls projecting in the direction of the steam flow.

The invention further consists in the improved partial admission turbines and details thereof hereinafter described.

In carrying the present invention into effect, according to one form, there is provided a suitable rotor carrying three rows of blades. This rotor is enclosed in a casing carrying two rows of stationary guide blades, which are positioned between the rotating blades.

At one side of the rotor a nozzle is provided, so arranged as to deliver working

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fluid against one of the rows of rotating blades, from which it passes to a row of guide blades, then to the second row of rotating blades, and so on.

The nozzle comprises a sector of guide vanes so disposed as to direct the working fluid upon the first row of moving blades in the required direction, and to cause the required expansion of the fluid.

The height of the blades both stationary and moving increases successively from the nozzle side of the rotor, the rows of rotating blades being continuous round the periphery of the rotor.

The stationary blades only extend over sectors of the rotor circumference, and each sector of stationary blades is provided with short end blockings, such as are described in the Specification of Letters Patent No. 28,047, of 1907.

The second sector of guide blades encountered by the working fluid may be of greater circumferential extent than the first sector, and may be displaced circumferentially with respect to the first sector.

Both the rotating blades and the stationary blades are provided with end tightening means, such as are described in the Specification of Letters Patent No. 12,347 of 1901.

Assuming that the nozzle and rows of blades described constitute the whole of the expanding devices of a given turbine, then the nozzle is made of such proportions that the largest percentage of pressure drop occurs in the nozzle, whilst a small pressure drop, *viz.*, the excess of pressure (over the counter pressure of the wheel chamber), remaining in the jets of working fluid issuing from the nozzle, takes place during the passage of the working fluid through the fixed and moving blades, by which means a large total energy per stage can be employed without undue loss by spilling over the blades and leakage through the clearance spaces surrounding the blades, and the percentage loss on this account is thereby greatly reduced.

In some cases the nozzle is arranged so that its outer face is placed in contact with the stator carrying the guide blades, and labyrinth or other suitable form of packing is provided between the nozzle and the adjacent part of the rotor. By this means, leakage of steam from the space between the nozzle and the first row of moving blades is prevented, or very much reduced. This space is subjected to the highest pressure of the stage posterior to the nozzle, and therefore requires the most effective packing.

Under certain conditions, it is desirable to provide at the exit side of the blades both moving and stationary axial projections of the inner and outer constraining walls for example, the packing sections and shrouds respectively of the passage through the blades through which the working fluid passes.

According to a modification, an initial stage similar to that already described is provided, in combination with a succeeding stage or stages of ordinary reaction or "Parsons" blading, the whole being situated within a common casing.

In turbines constructed according to this modification, the nozzle of the initial stage is made of such proportions that the largest percentage of pressure drop which it is intended shall occur in that stage takes place in the nozzle, whilst a small pressure drop, *viz.*, the excess of pressure (over the counter pressure of the wheel chamber,) remaining in the jets of working fluid issuing from the nozzle, takes place during the passage of the working fluid through the stationary and moving blades of the initial stage. The reaction blading expands the working fluid from the pressure of the wheel chamber down to the pressure existing in the exhaust conduit.

According to one form of this modified construction, the reaction blading may be arranged to work with complete annular admission of working fluid; while in another form, the reaction stages may be arranged to operate with partial admission, in which case the guide blades of the reaction stage are formed with short end blockings.

In certain cases, turbines constructed according to this modified construction

may have the initial stage in the form of a wheel, and the "Parsons" reaction blading stage or stages formed of drum construction.

Again, in some cases the reaction blading may be situated in the same annular space as the blading of the initial stage, in which case a drum construction may be employed for both parts.

In certain forms of this modified construction, both the "Parsons" reaction stages and the initial stage may be provided with end tightening means, such as are described in the Specification of Letters Patent No. 12,347 of 1901.

In certain cases, the blading both stationary and moving in the initial stage and in the succeeding reaction stage or stages may be provided with end tightening means in conjunction with axial projections of the constraining walls on either or both sides.

Such axial projections may take the form in some cases of plain thinned edges to the blade end tightening means. In other cases, the edge may be bent down towards the base of the adjacent blade row.

In certain cases, the axial projections may be formed upon the strips which contain the roots of the blades, and may be reduced to a thin edge so as to wear away without heating in the event of contact taking place.

Similar axial projections may in certain cases be formed upon or attached to the nozzle mouth.

Again, in certain cases, the blade end tightening means may be provided with an axial projection parallel with the axis of rotation of the rotor, in conjunction with an additional projecting element adapted to co-act with adjacent bladings to prevent spilling of the working fluid.

It will be understood that the axial projections may be provided on either or both sides of the blades, and serve respectively on the outlet and inlet sides to direct the working fluid issuing from and collect the working fluid entering rows of blades, while the end tightening means with which they are associated serve to prevent any leakage due to excess of pressure between the blades over that of the chamber containing the blade rows.

According to a second modification, a succession of stages similar to the first described form are provided, the stages being separated from one another by nozzles of the barrier type, such as are described in the Specification of Letters Patent No. 27,907 of 1908. In turbines according to this modification, the nozzles are so proportioned that in each stage the largest percentage of pressure drop of that stage occurs in the nozzle.

According to a further modified construction, a succession of stages similar to the first described form are provided, the stages being separated by nozzles of the type described in the Specification of Letters Patent No. 29,119 of 1909.

It will be seen that by the above described constructions, a highly efficient turbine is obtained, while the design of the turbine is not so restricted by special power conditions as heretofore.

For example, with turbines having initial impulse stages, the output of which is regulated by the number of nozzles in action in the first stage or stages, when reduced power is being developed, and the number of operative nozzles is reduced, the pressure drop per stage thus regulated increases, and an increased area through the blades would become necessary to pass the steam without a large pressure drop across the blades. At the lowest powers, in ship propulsion installations, such area is not practicable, as an area suitable for the lowest power conditions would not be suitable for the full power conditions, and *vice versa.*

Further, it is well known that in velocity compounded impulse stages, the output of the later rows is successively less than that of the first rows of blades. This can be substantially overcome in turbines according to the present invention by arranging the areas for flow of working fluid through the successive rows of blades so that suitable pressure drops occur over the blades, this pressure drop overcoming the friction and maintaining a higher

velocity in the later blades, the turbine stage according to the present invention thus being a combined impulse and reaction stage with a gradual change from the former to the latter.

With turbines as hitherto constructed, such an arrangement of areas for steam flow through the blades would be impracticable, as the loss by leakage would more than counterbalance any advantage gained.

Dated this 18th day of June, 1915.

MARKS & CLERK.

COMPLETE SPECIFICATION.

Improvements in and relating to Partial Admission Turbines.

We, The Honourable Sir Charles Algernon Parsons, K.C.B., of Heaton Works, Newcastle-upon-Tyne, in the County of Northumberland, Engineer, Stanley Smith Cook, and Robert Howe, both of Turbinia Works, Wallsend-upon-Tyne, in the County of Northumberland, Engineers, do hereby declare the nature of this invention and in what manner the same is to be performed, to be particularly described and ascertained in and by the following statement:—

The present invention relates to partial admission turbine stages of the type in which the working fluid expands chiefly within the first guide means, the velocity energy and the residual pressure energy being subsequently fractionally absorbed in one or more rows of moving blades and alternated rows of stationary blades, and in which the said stationary blades only extend over sectors of the rotor circumference, each sector being provided with short end blockings.

The present invention relates more particularly to partial admission turbine stages of the above type in which the working fluid expands chiefly within the first guide means; the expansion which takes place in the successive moving and stationary blades being only a slight fraction of the total expansion of that stage.

The present invention consists in a turbine stage of the type indicated, in which short end blockings are employed, such as are described in the Specification of Letters Patent No. 28,047 of 1907, together with end tightening means for the blades, such as are described in the Specification of Letters Patent No. 12,347 of 1907, whereby the loss by spilling over the blades, and the leakage through the clearance spaces surrounding the blades, are reduced.

The invention further consists in a turbine having an initial stage constructed according to the preceding paragraph succeeded by a stage or stages of ordinary "Parsons" reaction blading, some or all of these latter stages being of either the partial admission type, or of the annular admission type.

The invention further consists in a turbine stage according to the third paragraph, in which the outer face of the nozzle is placed in contact with the stator carrying the guide blades, labyrinth or other suitable form of packing being provided between the nozzle and the adjacent part of the rotor, whereby leakage of steam from the space between the nozzle and the first row of blades is prevented or considerably reduced.

The invention further consists in turbine stages or turbines, as described in the last three paragraphs, in which either or both of the inlet and exit sides of the blades have prolongations of the constraining walls projecting in the direction of the steam flow.

The invention further consists in the improved partial admission turbines and details thereof hereinafter described.

Referring to the accompanying diagrammatic drawings:—

Figure 1 is a diagrammatic cross-section through a turbine stage embodying the present invention, the section being taken on the line X—X of Figure 2.

Figure 2 is a diagrammatic developed sectional plan on the line Z—Z of Figure 1.

Figure 3 is a similar section to Figure 1 through a modified form of turbine stage, the section being taken on the line Y—Y of Figure 4.

Figure 4 is a diagrammatic developed sectional plan on the line W—W of Figure 3.

Figure 5 is a cross-section on the line A—A of Figure 3.

Figure 6 is a diagrammatic longitudinal section illustrating a modified form of the invention in which a drum construction carrying reaction or "Parsons" blading is employed in the later stages.

Figure 7 is a longitudinal section showing the end tightening of blades in the first stage of a turbine and unshrouded reaction blades in the succeeding stage. Figure 7 also illustrates the relative position and packing of the nozzle.

Figure 8 is a similar cross-section to Figure 7 in which all the blades have end tightening means.

Figure 9 illustrates further forms of end tightening.

Figure 10 illustrates a further form of end tightening in which axial extensions are provided on the inlet and exit sides of certain of the blades.

Figures 11 and 12 illustrate the application of axial extensions to the nozzle mouth.

Figure 13 illustrates end tightening in which extensions are provided on one side only of the blades.

Figure 14 illustrates the use of barrier nozzles of the type disclosed in the Specification of Letters Patent No. 27,907 of 1908, while

Figure 15 illustrates the application of nozzles of the type described in the Specification of Letters Patent No. 29,119 of 1909.

In carrying the present invention into effect according to one form, and as shown in Figures 1 and 2 applied to a single stage turbine, there is provided a suitable rotor 1 carrying three rows of blades 2, 3, 4. This rotor is enclosed in a casing or stator 5 carrying two rows of stationary guide blades 6, 7, which are positioned between the rotating blades.

At one side of the rotor a nozzle 8 is provided, so arranged as to deliver working fluid against one of the rows of rotating blades, from which it passes to a row of guide blades, then to the second row of rotating blades, and so on.

The nozzle 8 comprises a sector of guide vanes 9 so disposed as to direct the working fluid upon the first row 2 of moving blades in the required direction, and to cause the required expansion of the fluid.

The height of the blades both stationary and moving increases successively from the nozzle side of the rotor, the rows of rotating blades 2, 3, 4, being continuous round the periphery of the rotor.

The stationary blades 6, 7 only extend over sectors of the rotor circumference, and each sector of stationary blades is provided with short end blockings 10, such as are described in the Specification of Letters Patent No. 28,047 of 1907.

The second sector of guide blades, *viz.*, blades 7, encountered by the working fluid may be of greater circumferential extent than the first sector, *viz.*, blades 6, and may be displaced circumferentially with respect to the first sector.

Both the rotating blades and the stationary blades are provided with end tightening means, such as are described in the Specification of Letters Patent No. 12,347 of 1901.

Assuming that the nozzle 8 and rows of blades 2, 3, 4, 6 and 7 described constitute the whole of the expanding devices of a given turbine, then the

nozzle 8 is made of such proportions that the largest percentage of pressure drop occurs in the nozzle, whilst a small pressure drop, *viz.*, the excess of pressure (over the counter pressure of the wheel chamber), remaining in the jets of working fluid issuing from the nozzle, takes place during the passage of the working fluid through the fixed and moving blades 2, 3, 4, 6 and 7, by which means a large total energy per stage can be employed without undue loss by spilling over the blades and leakage through the clearance spaces surrounding the blades, and the percentage loss on this account is thereby greatly reduced.

It will thus be seen that a turbine stage according to the present invention commences as an impulse stage and finishes as a reaction stage, with a gradual change from the former to the latter.

In some cases, as shown in Figures 5 to 13, the nozzle is arranged so that its outer face is placed in contact with the stator 5 carrying the guide blades, and labyrinth packing, such as 11, is provided between the nozzle 8 and the adjacent part of the rotor. Any other suitable form of packing may be employed except such forms as depend on the maintenance of a small radial clearance. By this means, leakage of steam from the space 12 between the nozzle and the first row of moving blades is prevented, or very much reduced. This space is subjected to the highest pressure of the stage posterior to the nozzle, and therefore requires the most effective packing.

Under certain conditions, it is desirable to provide at the exit side of the blades both moving and stationary axial projections of the inner and outer constraining walls, for example, the packing sections and shrouds respectively of the passage through the blades through which the working fluid passes.

According to a modification, see Figures 3, 4 and 5, an initial stage similar to the turbine already described with reference to Figures 1 and 2 is provided, in combination with a succeeding stage or stages of ordinary reaction or "Parsons" blading, 15, 16, the whole being situated within a common casing.

In turbines constructed according to this modification (Figures 3 and 4) the nozzle 8 of the initial stage is made of such proportions that the largest percentage of pressure drop which it is intended shall occur in that stage takes place in the nozzle, while a small pressure drop, *viz.*, the excess of pressure (over the counter pressure of the wheel chamber) remaining in the jets of working fluid issuing from the nozzle, takes place during the passage of the working fluid through the stationary and moving blades 6, 7, and 2, 3, 4, of the initial stage. The reaction blading expands the working fluid from the pressure of the wheel chamber down to the pressure existing in the exhaust conduit.

According to one form of this modified construction, and as shown in Figure 4, the reaction stages may be arranged to operate with partial admission, in which case the guide blades 15 of the reaction stage are formed with short end blockings 10; while, in another form, the reaction blading may be arranged to work with complete annular admission of working fluid.

In certain cases (see Figure 6) turbines constructed according to this modified construction may have the initial stage in the form of a wheel 17, and the "Parsons" reaction blading stage or stages 18 formed of drum construction 19.

Again, in some cases, see Figure 7, the reaction blading 18 may be situated in the same annular space as the blading 2, 3, 4, 6, 7, of the initial stage, in which case a drum construction 19 may be employed for both parts.

In certain forms of this modified construction, both the "Parsons" reaction stages and the initial stage may be provided with end tightening means, such as are described in the Specification of Letters Patent No. 12,347 of 1901.

In certain cases, the blading both stationary and moving in the initial stage

(see Figure 7) and in the succeeding reaction stage or stages (see Figure 8) may be provided with end tightening means 13 in conjunction with axial projections of the constraining walls on either or both sides.

Such axial projections may take the form in some cases of plain thinned edges 14 to the blade end tightening means 13. In other cases, the edge may be bent down towards the base of the adjacent blade row, as shown at 20.

In certain cases, the axial projections may be formed upon the strips which contain the roots of the blades, as shown at 21 (Figures 7—10) and may be reduced to a thin edge, as shown in Figures 9 and 10, so as to wear away without heating in the event of contact taking place.

Similar axial projections may in certain cases be formed upon or attached to the nozzle mouth (see Figures 11 and 12).

Again, in certain cases (see Figure 10) the blade end tightening means 13 may be provided with an axial projection 14 parallel with the axis of rotation of the rotor, in conjunction with an additional projecting element 22 adapted to co-act with adjacent bladings to prevent spilling of the working fluid.

It will be understood that the axial projections may be provided on either or both sides of the blades, and serve respectively on the outlet and inlet sides to direct the working fluid issuing from and collect the working fluid entering rows of blades, while the end tightening means with which they are associated serve to prevent any leakage due to excess of pressure between the blades over that of the chamber containing the blade rows.

According to a second modification (see Figure 14) a succession of stages similar to the first form described with reference to Figures 1 and 2 are provided, the stages being separated from one another by nozzles of the barrier type, such as are described in the Specification of Letters Patent No. 27,907 of 1908. In turbines according to this modification, the nozzles 8 are so proportioned that in each stage the largest percentage of pressure drop of that stage occurs in the nozzle.

According to a further modified construction (see Figure 15) a succession of stages similar to the first described form (Figures 1 and 2) are provided, the stages being separated by nozzles of the type described in the Specification of Letters Patent No. 29,119 of 1909.

It will be seen that by the above described constructions, a highly efficeint turbine is obtained, while the design of the turbine is not so restricted by special power conditions as heretofore.

For example, with known turbines having initial impulse stages, the output of which is regulated by the number of nozzles in action in the first stage or stages, when reduced power is being developed, and the number of operative nozzles is reduced, the pressure drop per stage thus regulated increases, and an increased area through the blades would become necessary to pass the steam without a large pressure drop across the blades. At the lowest powers, in ship propulsion installations, such area is not practicable, as an area suitable for the lowest power conditions would not be suitable for the full power conditions, and *vice versa*.

Further, it is well known that in velocity compounded impulse stages, the output of the later rows is successively less than that of the first rows of blades.

This defect can be substantially overcome in turbines according to the present invention by arranging the areas for flow of working fluid through the successive rows of blades so that suitable pressure drops occur over the blades, these pressure drops overcoming the friction and maintaining a higher velocity in the later blades, the turbine stage according to the present invention thus being a combined impulse and reaction stage with a gradual change from the former to the latter.

With turbines as hitherto constructed, such an arrangement of areas for steam flow through the blades would be impracticable, as the loss by leakage would more than counterbalance any advantage gained.

Having now particularly described and ascertained the nature of our said invention and in what manner the same is to be performed, we declare that what we claim is:—

1. In a turbine stage of the type in which the working fluid expands chiefly within the first guide means and the velocity energy and the residual pressure energy are subsequently fractionally absorbed in one or more rows of moving blades and alternated rows of stationary blades, the use of short end blockings such as are described in the Specification of Letters Patent No. 2[illegible] of 1907, together with end tightening means for the blades such as are described in the Specification of Letters Patent No. 12,347 of 1901, whereby losses by spilling over the blades and leakage through the clearance spaces surrounding the blades are reduced.

2. A turbine having an initial stage as claimed in Claim 1, succeeded by a stage or stages of ordinary "Parsons" reaction blading, some or all of these latter stages being of either the partial admission type or of the annular admission type.

3. A turbine stage as claimed in Claim 1, in which the outer face of the nozzle is placed in contact with the stator carrying the guide blades, labyrinth or other suitable form of packing which does not depend on the maintenance of a definite radial clearance for tightness, being provided between the nozzle and the adjacent part of the rotor, whereby leakage of steam from the space between the nozzle and the first row of blades is prevented or considerably reduced, substantially as described.

4. A turbine comprising two or more stages as claimed in Claim 1, the stages being separated from one another by nozzles of the barrier type, such as are described in the Specifications of Letters Patent Nos. 27,907 of 1908 or 29,119 of 1909.

5. The improved partial admission turbines and details thereof, substantially as hereinbefore described with reference to the accompanying drawings.

Dated this 18th day of January, 1916.

MARKS & CLERK.

Redhill: Printed for His Majesty's Stationery Office, by Love & Malcomson, Ltd.—1916.

ERRATA.

SPECIFICATION No. 9005, A.D. 1915.

Page 4, line 34, *for* "1907" *read* "1901"
,, 7, ,, 34, *for* "efficeint" *read* "efficient"

PATENT OFFICE,
September 26th, 1916.

A.D. 1915 JUNE 18. No. 9005.

(3 SHEETS)
SHEET 1

PARSONS & others' COMPLETE SPECIFICATION.

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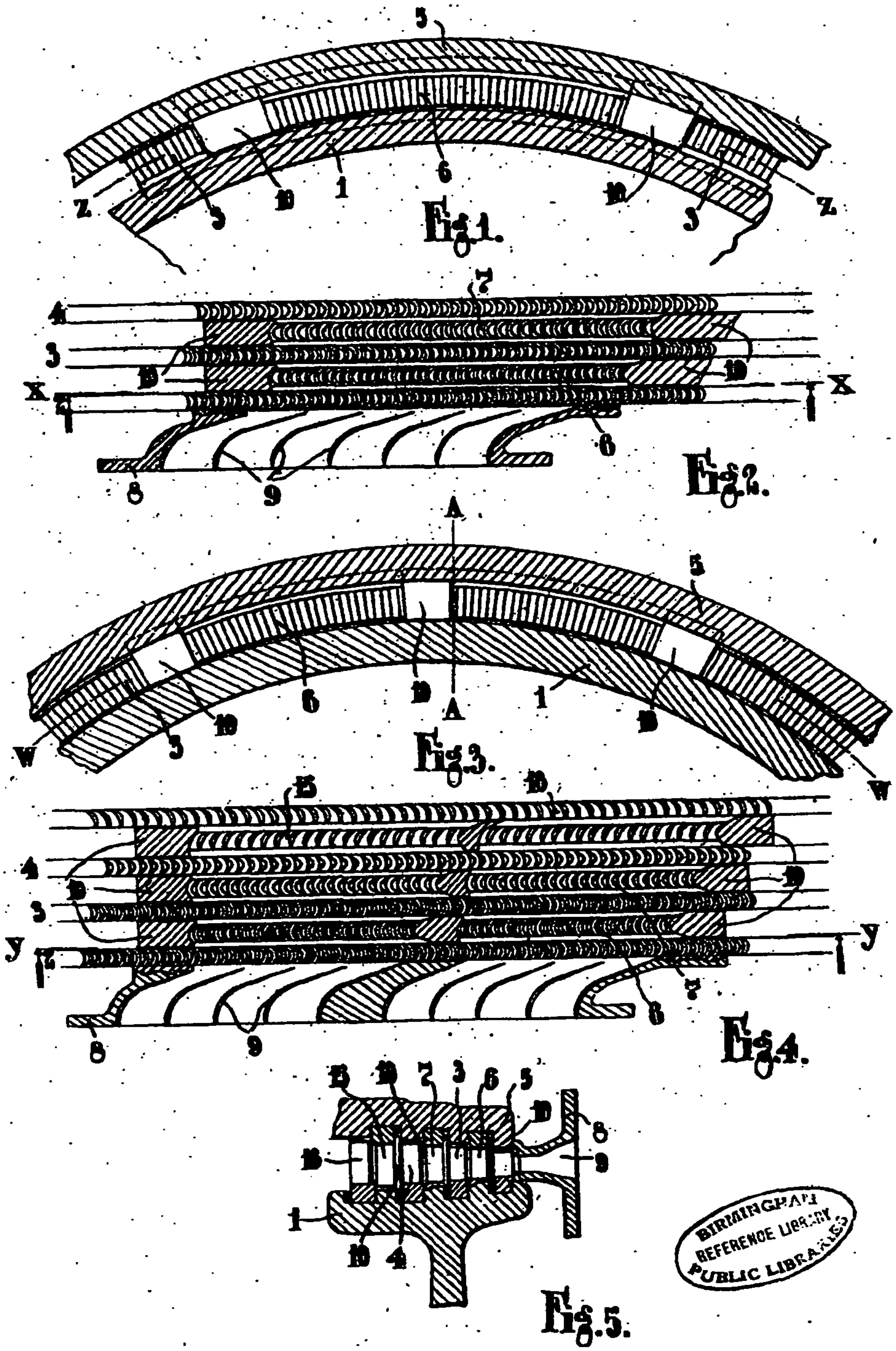

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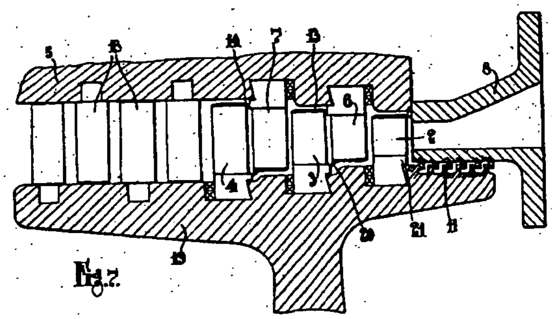

Fig. 7.

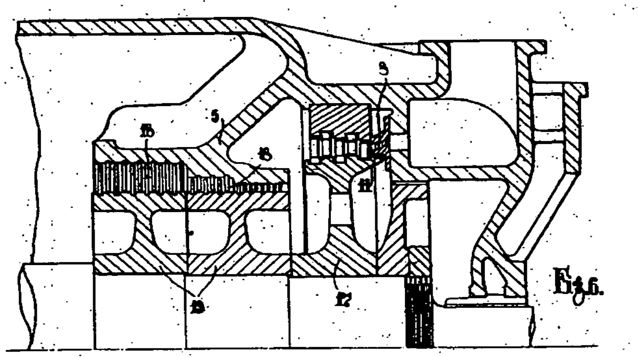

Fig. 6.

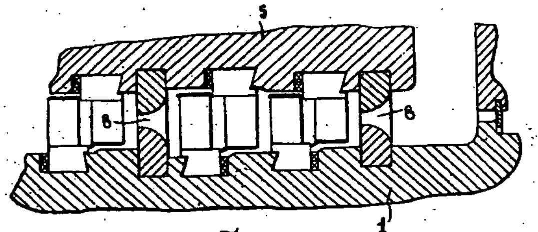

Fig. 14.

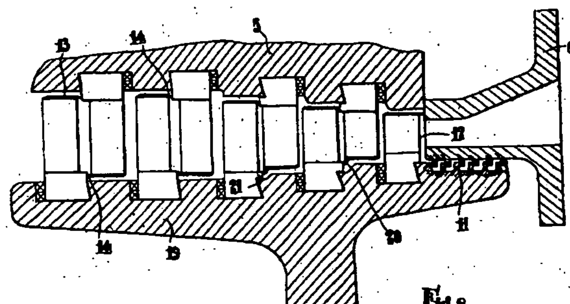

Fig. 8.

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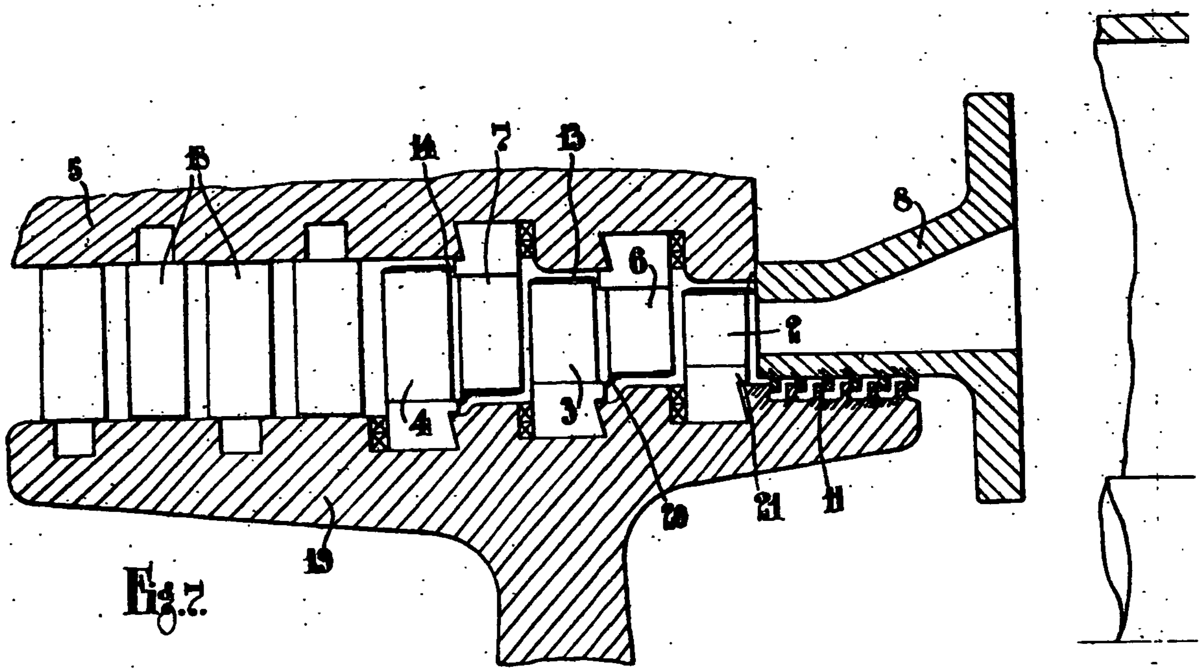

Fig. 7.

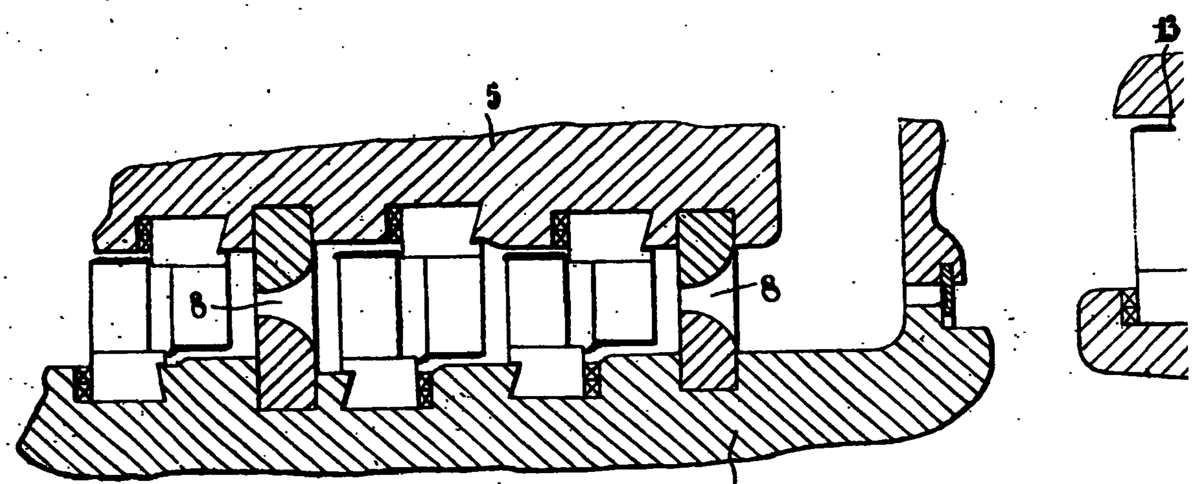

Fig. 14.

(3 SHEETS)
SHEET 2.

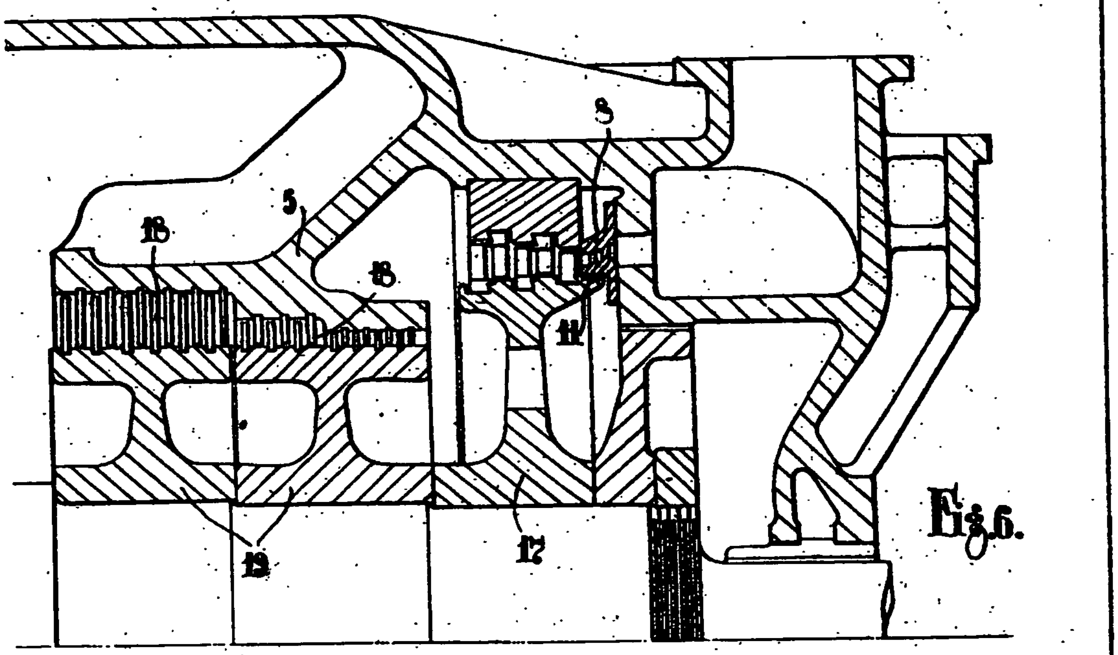

Fig.6.

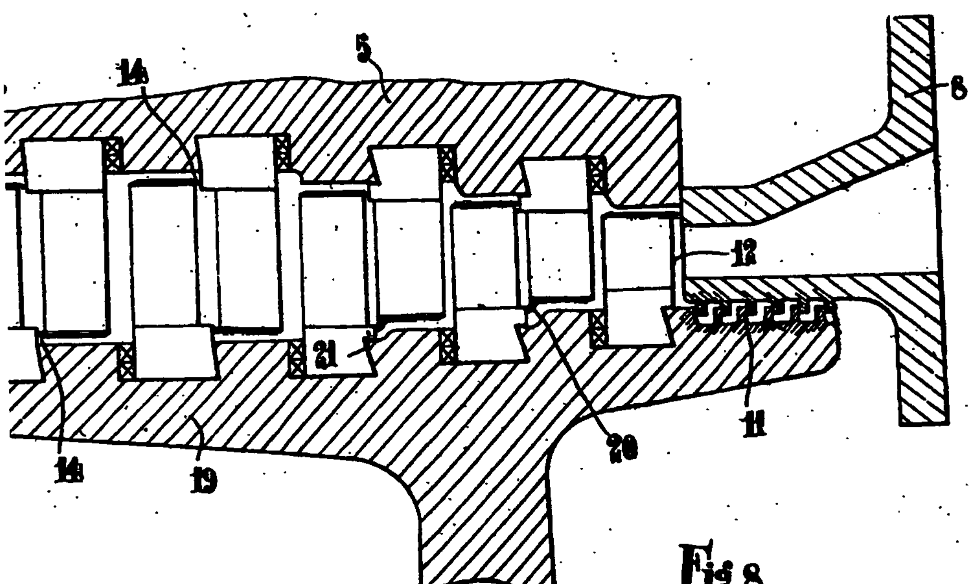

Fig.8.

Malby & Sons, Photo-Litho.

[This Drawing is a full-size reproduction of the Original.]

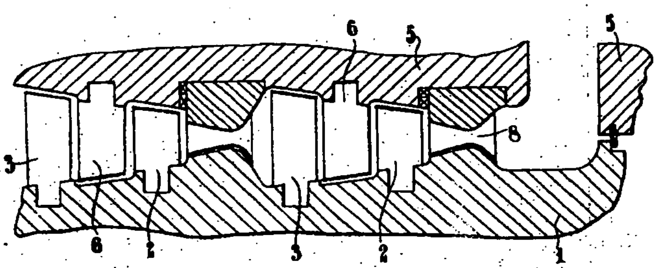

Fig. 15.

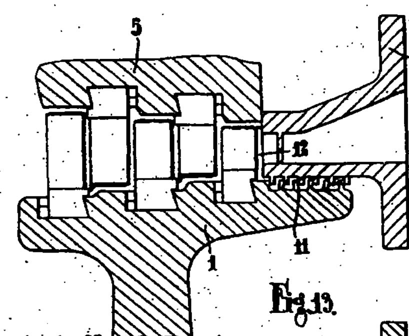

Fig. 13.

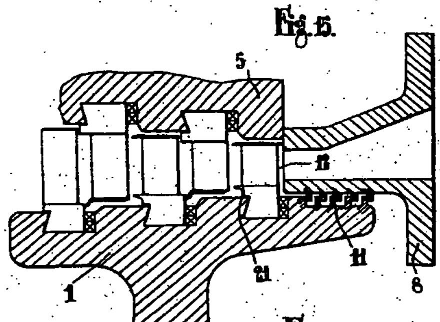

Fig. 9.

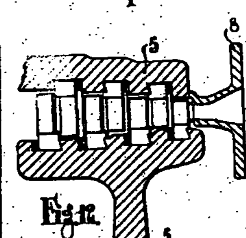

Fig. 12.

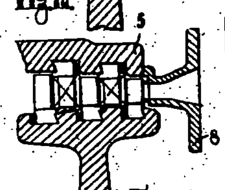

Fig. 11.

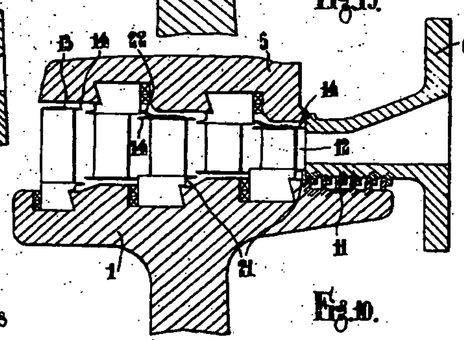

Fig. 10.

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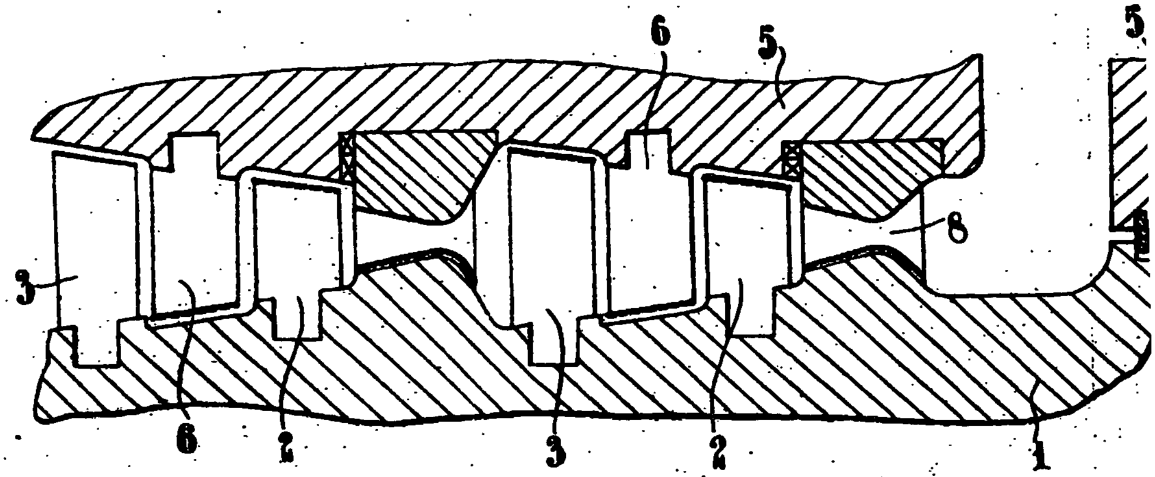


Fig. 15.

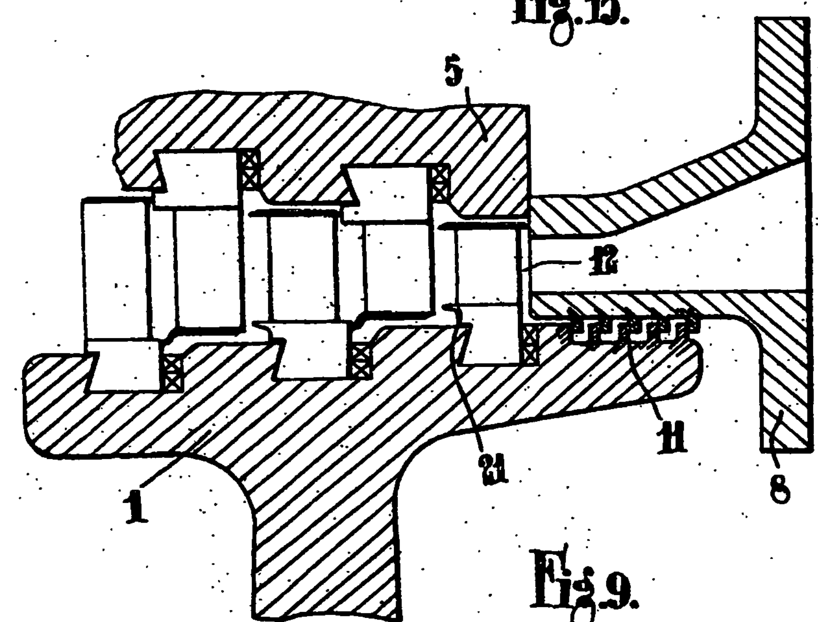


Fig. 9.

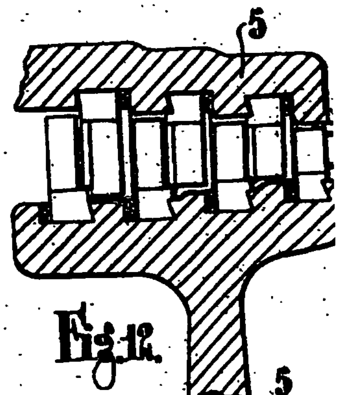


Fig. 12.

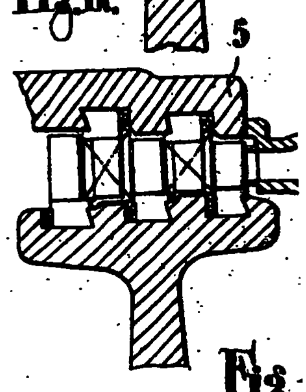


Fig.

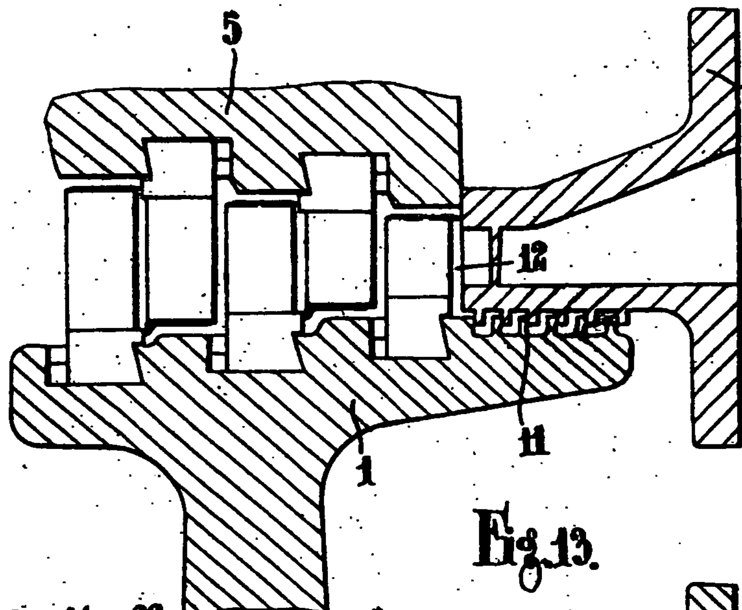


Fig. 13.

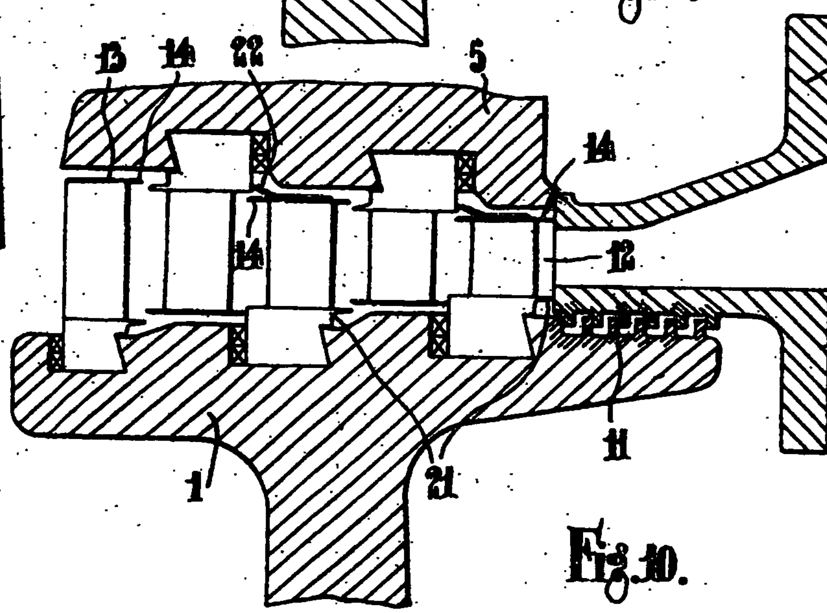
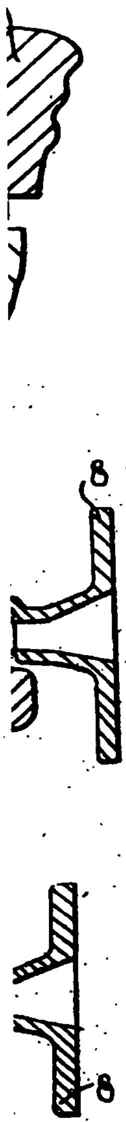


Fig. 10.



11.

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